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Recruitment and Retention in University Makerspaces: A Systematic Literature Review

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Abstract

University makerspaces serve as informal learning environments that support hands-on exploration, collaborative problem-solving, and technical skill development. Despite their educational benefits, participation in makerspaces remains inconsistent, with students facing barriers related to recruitment and retention. This systematic literature review examines strategies used to attract new users and retain existing participants in educational makerspace environments. Through a comprehensive search of peer-reviewed literature published from 2009 onward, 17 studies were identified and analyzed using inductive coding methods. Five interconnected themes emerged from the analysis. Findings indicate that recruitment is shaped by physical aesthetics, structured entry points, and social accessibility, while retention is strongly associated with ongoing mentorship from the makerspace staff, a sense of belonging, and perceived value. The review highlights that marginalized and minoritized students face compounded barriers related to representation, gatekeeping, and inequitable access. These findings suggest that improving makerspace participation requires coordinated attention to environmental design, social dynamics, identity signaling, and equity-centered practices. This review contributes to understanding how makerspaces can better support inclusive and sustained engagement in engineering education.

Keywords: undergraduate, studio, makerspace, systematic review

Introduction

University makerspaces support hands-on learning, collaborative problem-solving, and student-driven exploration, complementing traditional engineering instruction [1]. These environments help students develop technical competence, creative confidence, and engineering identity through iterative design and prototyping activities [2] and by encouraging students to take ownership of their ideas within a supportive community [3].

Despite these benefits, participation in makerspaces is often inconsistent across institutions. Previous research describes several recruitment challenges, including student uncertainty about expected norms, limited awareness of available resources, and feelings of intimidation when approaching unfamiliar tools or equipment [4]. Retention challenges also emerge when students encounter unclear pathways for skill development, struggle to navigate early setbacks, or have difficulty forming social connections in the space [5]. These factors influence whether students choose to begin participating and whether they continue returning after an initial visit.

Makerspaces rely on self-directed learning and peer interaction by design. However, many students may not feel comfortable defining their own goals and pursuing time in a makerspace without direction [24]. Motivational strategies used in educational settings, including elements typically associated with gamified learning environments, may offer insight into how

participation in makerspaces can be supported. Prior research shows that elements such as challenges, badges, or structured progression can influence engagement, persistence, and the development of competence and autonomy [6]. Understanding how these motivational features shape participation is relevant for improving both recruitment and retention.
This study aims to identify recruitment and retention patterns that may inform future gamified interventions within makerspaces and provide guidance to improve student engagement in makerspaces. To identify these patterns, a systematic literature review was performed guided by two research questions: *(1) What strategies are used to attract new users to makerspaces? And (2) What strategies are used to retain makerspace users past an initial experience?*

Background

The following section provides an overview of how makerspaces are defined and summarizes the advantages and participation challenges described in prior research.

Makerspaces as Informal Learning Environments

Makerspaces began to gain prominence in educational settings in the late 2000s and early 2010s, influenced by the broader maker movement and increasing access to digital fabrication technologies [7]. Early adoption of makerspaces in universities and schools was driven by interest in hands-on learning, interdisciplinary collaboration, and opportunities for students to engage in design and prototyping outside of formal coursework [8]. As these spaces became more common, researchers began to examine their role as informal learning environments that support experimentation, creativity, and self-directed learning [1].

Makerspaces are commonly described as informal learning environments that provide tools and materials to support hands-on experience with making, iterating, and collaborating [1], [3]. Rather than following structured curricula, students pursue self-selected projects and learn through trial, error, and peer interaction, allowing participants to pursue projects aligned with their personal interests and goals [4], [9]. This approach enables learners to move between roles as novices, collaborators, and mentors depending on the context of the activity and their level of experience [10]. These characteristics have positioned makerspaces as sites for experiential learning that complement formal engineering and design education.

Studies in engineering education suggest that participation in makerspaces supports the development of technical competence, creative confidence, and engineering identity [2]. Engagement in iterative design and prototyping allows students to apply theoretical knowledge in practical contexts while developing problem-solving skills [11]. Makerspaces have also been shown to foster a sense of belonging by creating opportunities for social interaction and peer learning across disciplines and experience levels [12].

As makerspaces emphasize autonomy and self-directed learning, student experiences are shaped not only by access to tools but also by the social and cultural dynamics of the space [13]. These characteristics distinguish makerspaces from traditional instructional environments and influence how students engage, persist, and develop confidence over time [5]. Understanding these defining features is essential for examining factors that affect participation and continued involvement in makerspace environments.

Perceived Challenges for Recruitment and Retention in Makerspaces

Although makerspaces offer many educational benefits, the literature identifies several challenges that limit participation and sustained engagement. These challenges are often social, cultural, and structural rather than purely technical, and they shape how students perceive and experience makerspace environments [4]. As a result, not all students who could benefit from makerspaces choose to participate or continue engaging over time.

Research highlights multiple barriers that affect students' initial entry into makerspaces. Students may feel intimidated by unfamiliar tools or uncertain about whether they are welcome to use the space, particularly when norms and expectations are not made explicit [5]. Limited awareness of available resources and support can further discourage participation, especially among students with little prior experience or those who do not see themselves represented among current users [3]. These factors influence whether students decide to enter a makerspace for the first time.

Challenges related to continued participation often emerge after an initial visit. Research suggests that students may be less likely to return when they encounter unclear pathways for skill development, lack sufficient guidance during early experiences, or experience repeated setbacks without support [10]. Social factors also play a role. Difficulty forming connections with peers or staff can limit a student's sense of belonging, which has been linked to lower persistence in informal learning environments [13]. Together, these factors shape whether students remain engaged over time.

These challenges are particularly important because they can limit the extent to which makerspaces fulfill their educational potential. When participation is uneven, the benefits associated with hands-on learning, creative exploration, and identity development may be realized by only a subset of students [12]. These challenges underscore the need for approaches that support broader access, inclusion, and sustained engagement within makerspace environments.

Methods

This section describes the methodological approach used to conduct the systematic literature review. It outlines the literature search, data collection and classification, and the strategies used for data extraction, analysis, and coding to ensure transparency and rigor throughout the review process.

Literature Search

A systematic literature search [14], [15] was conducted to identify peer-reviewed studies related to makerspaces and participation challenges in these contexts. Searches were performed using Scopus, Web of Science, and ERIC, as these databases index research commonly published in engineering education, learning sciences, and higher education research.

Search terms were organized into four categories. The first category included makerspace-related terms such as makerspace, maker space, and fabrication lab to account for variation in terminology across the literature [7]. The second category included participation-related terms such as recruitment, retention, engagement, and participation. The third and fourth categories included contextual terms related to educational settings and student populations to refine search results and ensure relevance to higher education makerspaces.

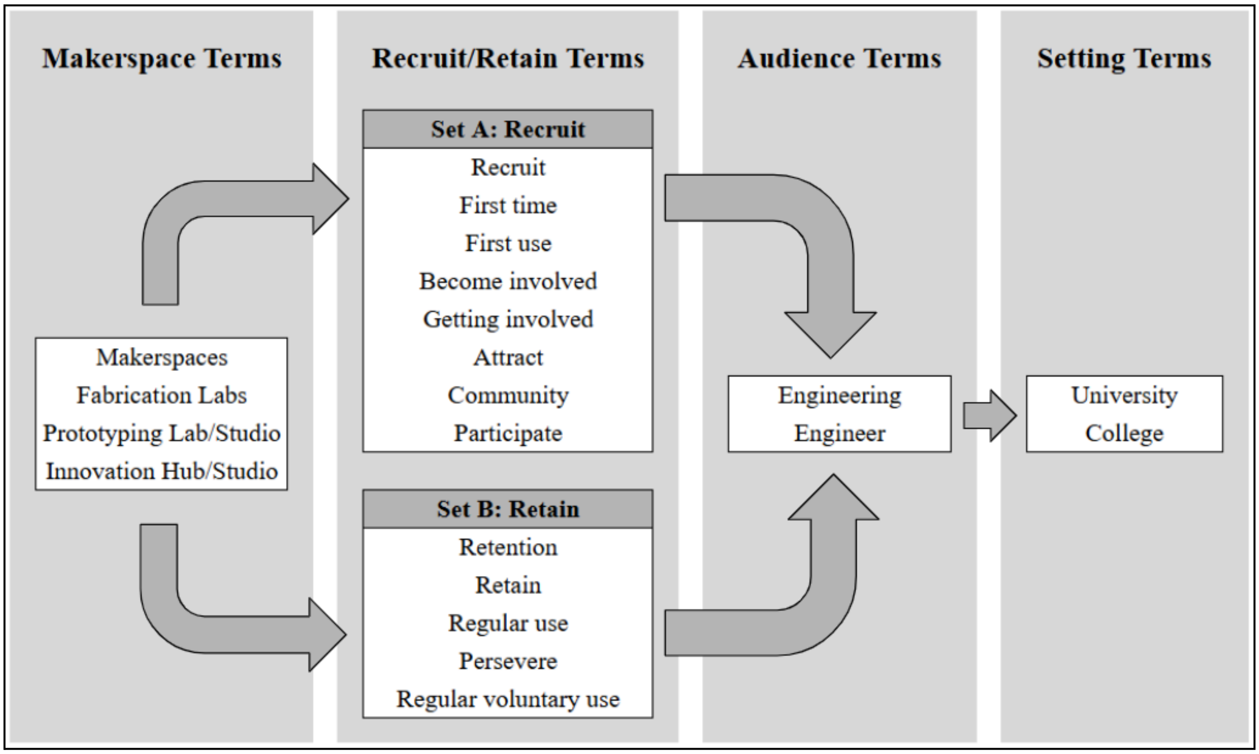

Figure 1: Search query generation flow chart

Combinations of terms across categories were used to identify studies that examined participation patterns and challenges within educational makerspace environments. To reflect the timeframe in which makerspaces started appearing more prominently within educational settings, we limited our search to peer-reviewed journal articles and conference papers published from 2009 onward [7]. Only studies written in English and focused on educational contexts were included. A total of 245 unique papers were exported for screening and further review.

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TITLE-ABS-KEY (makerspace OR "fabrication lab" OR "fab lab" OR "prototyping lab" OR "prototyping studio" OR "innovation hub" OR "innovation studio") ALL((recruit* OR "first time" OR "first use" OR enter* OR "new user" OR "become involved" OR "get involved" attract*) AND (engineer OR engineering) AND (university OR college)) AND ( DOCTYPE(ar OR cp))
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Figure 2. Example Scopus query string from the recruitment sub-search

Data Screening and Classification

A predetermined screening process with defined inclusion and exclusion criteria was used to identify studies relevant to this review. Studies were required to focus on makerspaces located within colleges or universities and to include undergraduate engineering students as participants. Studies were excluded if they focused on K–12 populations, even when conducted in university settings, or if they examined for-profit or non-institutional makerspaces. Papers that did not address participation, engagement, recruitment, or retention in educational makerspace contexts were also excluded.

Initial screening was conducted at the title level by two independent reviewers. Interrater reliability was assessed using percent agreement, which was 71 percent. Disagreements were resolved through discussion. Following title screening, 161 studies remained for abstract review. To support consistent application of the inclusion criteria, both researchers jointly reviewed 4 abstracts before performing an independent review of a subset of abstracts (16, or approximately 10% of the sample) to determine their level of agreement. The researchers had a 75 percent agreement on the subset of articles and so afterwards were able to proceed with independent abstract screening.

A full-text screening of 65 papers was conducted to determine final eligibility. During this phase, an initial subset of 10 full-text papers was screened independently by both researchers, resulting in 80 percent agreement. Following this assessment of agreement, one researcher reviewed each paper's abstract, introduction, and methods to assess alignment with the inclusion criteria. Following full-text screening, 17 papers were retained for classification and synthesis, as illustrated in Figure 3.

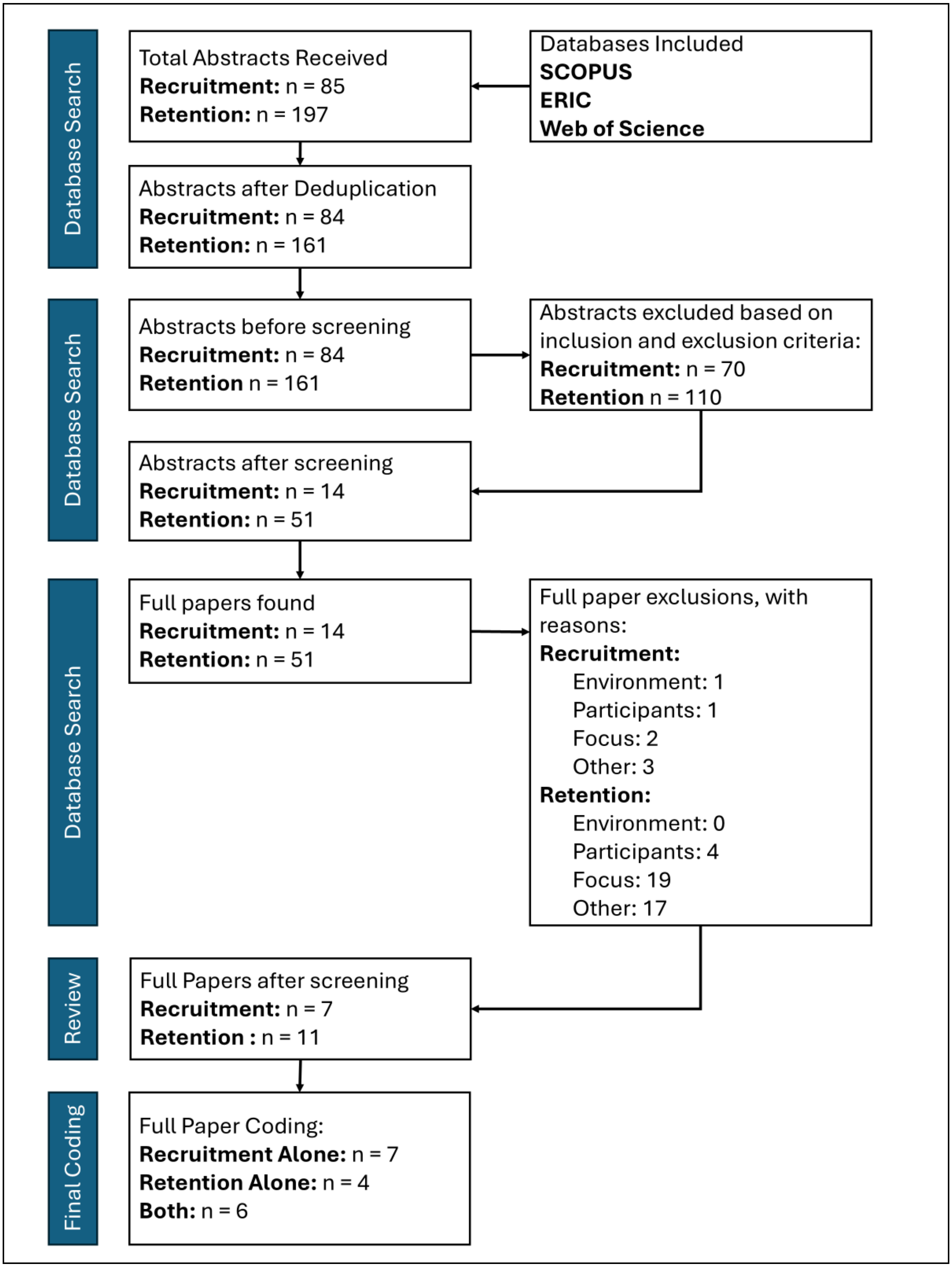

Figure 3: PRISMA paper exclusion flow chart

In total, 17 studies were retained for analysis. They were read in full and systematically classified using an inductive coding process. Recurring concepts identified across the studies were grouped into a set of codes, which were subsequently organized into broader thematic categories to capture patterns across the literature. These codes and themes form the basis of the results presented in this paper.

Coding Framework

The coding framework was developed through an iterative inductive process. Initial codes emerged from close readings of the 17 retained studies, with recurring concepts being identified and labeled. As patterns became apparent across multiple papers, codes were refined and grouped into broader categories. This process allowed themes to emerge organically from the data rather than being imposed a priori. The final coding framework consisted of 14 distinct codes organized into five overarching themes, as detailed in Table 1.

Table 1: Code Categorization and Definitions

Theme	Code	Definition
Design Considerations	*aesthetic*	How the makerspace is physically designed and how the space is maintained/organized
	catalyst opportunity	Events that are planned by the makerspace to recruit new student users (ex: holiday crafting night, club meeting, etc.)
	structured learning	Scaffolded progress in extracurricular projects or trainings centered in the makerspace
Community members	*mentorship*	Guidance given by student staff, faculty, or experienced users to first-time users
	social capital	Leveraging members of an existing social circle to enter or immerse oneself in the makerspace
	collaboration	Communal experiences within the makerspace between peers
Marginalized & Minoritized Groups	*sexism*	Negative gendered experiences within a makerspace
	diverse users	Attracting and retaining marginalized and minoritized students to the makerspace
Expected Values	*purpose*	Reasons for entering and participating in the makerspace

	interest and ownership	Engagement in the makerspace that is NOT motivated by external requirements or factors
Membership	*imposter syndrome and belonging*	An internalized feeling of encroachment or invasion into the makerspace
	gatekeeping	A pattern of behavior from regular users which discourages new users from joining
	intended audience and maker definition	How students define the ideal or typical user of the makerspace
	personal experience	Prior individual making experience influencing participation in the makerspace

Each of the 17 studies was systematically reviewed and assigned identification numbers corresponding to their database source and retrieval order. Papers were then classified according to which codes were present in their findings, methods, or discussion sections. This classification system allowed for systematic tracking of which participation factors appeared across multiple studies and enabled identification of patterns in how recruitment and retention strategies were conceptualized and studied.

Results and Discussion

This section presents the results of the systematic literature review and discusses the identified themes related to participation challenges in educational makerspaces. Findings are organized by thematic category to synthesize patterns across the reviewed studies with results touching on both how the theme was relevant to student recruitment and also retention.

Design Considerations

Design considerations refer to the physical, spatial, and programmatic features of makerspaces that shape how students perceive, access, and use the environment. This category includes both the material qualities of the space, such as aesthetics and organization, and the structured opportunities that mediate entry and learning within the makerspace.

Design considerations emerged as a key factor shaping recruitment into educational makerspaces. Across the reviewed studies, the physical aesthetics of a makerspace influenced students' initial perceptions of approachability and accessibility. Visual characteristics such as cleanliness, organization, lighting, and perceived complexity affected whether students felt comfortable entering the space for the first time [16], [17], [19]. Makerspaces described as sterile, overly technical, or visually overwhelming were often perceived as intimidating, particularly by students with limited prior fabrication experience who worried about misusing equipment or violating unspoken norms [17], [19]. In contrast, spaces that appeared actively used, creative, and student-centered signaled that novice participation was expected and acceptable, which lowered psychological barriers to entry [18], [20]. Planned catalyst opportunities such as workshops, open houses, or crafting nights further supported recruitment by giving students a socially sanctioned reason to enter the space and interact with tools, staff, and peers [22], [23], [19].

While aesthetics and entry points were central to recruitment, retention was influenced more strongly by how the space functioned over time and whether it supported sustained work. Returning users placed greater emphasis on reliable equipment, clear organization, visible maintenance, and predictable access to resources as indicators that the makerspace was a legitimate learning environment rather than a casual novelty space [18], [20]. Students also described frustration when tools were broken, materials were unavailable, or rules changed unpredictably, which reduced their willingness to return. In addition, structured learning opportunities such as scaffolded trainings, badge systems, or sequenced skill development pathways supported continued engagement by helping students build competence gradually and reducing anxiety about progressing independently [24], [25]. Together, these findings suggest that design considerations initially attract students through approachability and clarity, but retain them through usability, structure, and institutional care for the space.

Community Members

The community members category captures the social relationships, interactions, and forms of support that shape students' experiences in makerspaces. This includes mentorship from staff and peers, collaborative practices among users, and the role of social networks in facilitating or constraining participation.

Community members played a significant role in recruitment by shaping students' initial experiences within makerspaces. Several studies highlighted the importance of mentorship from student staff, peers, or faculty in reducing uncertainty for first-time users [22], [26], [27]. Access to approachable and knowledgeable individuals helped students navigate tools, norms, and expectations that were often implicit rather than formally documented. For students with limited prior experience, informal mentorship interactions increased confidence and reduced fear of making mistakes, which encouraged initial participation [26], [27]. The visible presence of supportive mentors also functioned as a social signal that help was available, making the space feel less exclusive and more welcoming. In some cases, peer invitations or existing social networks served as a key entry point, demonstrating how social capital could facilitate recruitment into makerspaces [22].

For retention, however, the role of community members became even more central. Studies consistently showed that students who formed ongoing relationships with peers and staff were more likely to return and remain engaged over time [22], [28], [25]. Collaborative practices such as working side by side on projects, sharing tools, or troubleshooting together fostered a sense of community that reinforced belonging and commitment to the space [28]. These relationships often extended beyond technical support, providing emotional encouragement and validation when students encountered challenges. At the same time, social dynamics could also hinder retention when experienced users dominated shared resources, formed closed groups, or dismissed novice questions [21], [29]. Such interactions reduced willingness to seek help and discouraged continued engagement, particularly among students who did not already identify as makers. Overall, the literature suggests that community members attract students to makerspaces through visibility and guidance, but keep them engaged through inclusive, sustained, and supportive relationships over time

Membership

The membership category refers to the social and cultural boundaries that define who is perceived as a legitimate makerspace participant. This includes how making and maker identities are constructed, communicated, and policed through institutional messaging, informal norms, and everyday interactions.

Perceptions of membership in makerspaces emerged as a distinct theme shaping participation across the reviewed studies. Beyond physical access and social interaction, students interpreted explicit and implicit signals that communicated who the makerspace was intended for and who was considered a legitimate participant. These signals were embedded in the physical environment, social norms, institutional messaging, and everyday interactions within the space. As a result, perceptions of membership influenced both initial engagement with makerspaces and students' long-term involvement.

With respect to recruitment, perceptions of membership shaped whether students viewed themselves as legitimate makerspace participants in the first place. Several studies described how narrow definitions of making and maker identity discouraged students without prior technical experience from entering makerspaces [26], [30], [32]. When makerspaces were framed primarily as engineering-focused environments filled with advanced machinery, students outside of engineering or those without prior fabrication experience often perceived themselves as outsiders [30]. In contrast, broader definitions of making that emphasized creativity, experimentation, art, and interdisciplinary work expanded perceptions of who could participate and supported more inclusive recruitment [26]. Messaging, signage, programming, and the types of projects highlighted in the space all contributed to whether students saw themselves represented as potential users [30].

For retention, membership was shaped less by first impressions and more by everyday experiences within the makerspace. Informal gatekeeping practices such as unspoken expectations around tool knowledge, confidence, or behavior created ongoing barriers to participation [25], [29]. In some cases, experienced users controlled access to tools or subtly signaled who did or did not belong, reinforcing hierarchical dynamics within the space. These practices were closely tied to imposter syndrome, as students who already questioned their competence became less willing to ask for help or return after negative experiences [19], [32]. Students described feeling like they did not truly belong unless they already had advanced skills, which contradicts the makerspace ideal of learning through doing. Conversely, environments that explicitly normalized learning, mistakes, and novice participation helped counteract imposter feelings and supported longer-term engagement [19].

Members

The members category examines how participation in makerspaces is shaped by inequities related to gender, race, and intersecting social identities. This category foregrounds how representation, power dynamics, and structural barriers differentially impact students' ability to enter and remain in makerspaces.

The reviewed studies indicate that recruitment into makerspaces was experienced differently by students from marginalized and minoritized communities. Gendered norms and male-dominated cultures discouraged some women and gender minoritized students from entering makerspaces, particularly when assumptions about technical competence were present [22], [27], [29]. Participants reported experiences in which their skills were questioned or their presence was treated as unusual, which reduced their willingness to try the space in the first place. Limited representation among staff, mentors, and frequent users further reinforced perceptions that makerspaces were designed primarily for white men, affecting initial engagement [29]. Students from racially minoritized backgrounds similarly described heightened awareness of belonging when makerspace norms aligned closely with majority cultural expectations, which shaped whether they felt comfortable entering the space [19], [30].

Retention challenges for these members were often cumulative rather than isolated. Even when students entered makerspaces, continued participation was shaped by ongoing experiences of subtle bias, exclusion, or pressure to prove competence [19], [27]. Structural barriers also played a significant role. Limited operating hours, inflexible scheduling, and expectations of unpaid labor disproportionately affected students with caregiving responsibilities, jobs, or commuting constraints [21], [25]. In addition, reliance on informal social networks for access to information or mentorship further marginalized students who were not already socially embedded in the makerspace community [25]. As a result, marginalized students were more likely to disengage over time, even when they valued the space and its resources. These findings suggest that recruitment barriers stem largely from representation and access, while retention challenges are driven by persistent social and structural inequities within makerspaces.

Expected Value

Expected value refers to how students perceive the meaning, relevance, and benefits of makerspace participation. This includes both instrumental outcomes such as skill development and academic utility, as well as personal outcomes related to empowerment, identity, and belonging.

Perceived value influenced recruitment by shaping students' initial motivation to engage with makerspaces. Several studies reported that students were drawn to makerspaces for opportunities to develop hands-on technical skills, explore personal interests, or connect academic learning with real-world applications [19], [26], [31]. When makerspaces were framed as relevant to coursework, research, or career preparation, students were more likely to try the space. Makerspaces also appealed to students seeking creative outlets or experiential learning beyond traditional classrooms. In contrast, when the purpose of the makerspace felt unclear or disconnected from students' goals, initial participation was less likely [26]. These perceptions of value influenced whether students viewed makerspace engagement as worth the investment of time and effort.

Retention was more closely tied to how value was experienced over time rather than initial expectations. Continued participation was strongly associated with feelings of empowerment, ownership, and identity development, not just technical skill acquisition [27], [30]. Makerspaces that supported autonomy, experimentation, and self-directed projects enabled students to take creative control over their work and see themselves as legitimate makers, which strengthened intrinsic motivation [30]. For some students, particularly those who felt marginalized in other academic spaces, makerspaces provided an alternative environment where they could build confidence, agency, and a sense of belonging [19]. Conversely, rigid rules, opaque expectations, or limited opportunities for creative decision making diminished perceived value and reduced long-term participation [27]. Overall, the literature suggests that value initially attracts students through perceived relevance but retains them through meaningful learning experiences, empowerment, and identity development.

Conclusions

This systematic literature review examined how makerspaces in higher education address challenges related to recruitment and retention. By synthesizing findings across 17 studies, the review identified five interconnected themes that shape participation: design considerations, community members, membership, marginalized and minoritized communities, and expected value. Together, these themes illustrate that participation in makerspaces is influenced by a complex interplay of environmental, social, and identity-related factors.

Design considerations by influencing how accessible, legible, and support makers appear to both new and existing users. Physical aesthetics, structured entry points, and learning pathways collectively contribute to students' decisions to enter, return to, and remain engaged in makerspace environments. Community members influence participation by shaping access to knowledge, support, and social networks. Mentorship, collaboration, and social capital support recruitment by reducing uncertainty and fostering retention by building connections and belonging. However, when social interactions are perceived as exclusive or unapproachable, they can reinforce participation barriers, highlighting the importance of intentional practices that promote inclusive social environments.

The literature indicates that membership is constructed through definitions of making and makers, informal gatekeeping practices, and identity signaling. These factors influence recruitment by shaping whether students see themselves as potential participants and affect retention by reinforcing or undermining students' sense of legitimacy within the space. This theme highlights the importance of critically examining how makerspaces communicate inclusion and define participation boundaries. For marginalized and minoritized students specifically, participation is shaped by structural and social inequities that extend beyond individual motivation or interest, including challenges related to representation, gatekeeping, and inequitable access. These compounded barriers underscore the need for equity-centered approaches when examining and designing for makerspace participation.

Expected value emerges as a key mechanism between recruitment and retention. When students perceive makerspaces as offering meaningful skill development, personal empowerment, and purpose aligned with their goals, identities, and aspirations, they are more likely to enter and remain engaged. This suggests that sustained participation depends not only on access or inclusion, but on the experiences that the students find personally and professionally meaningful. Across these themes, the findings indicate that recruitment is shaped by physical aesthetics, structured entry points, and social accessibility, while retention is more strongly associated with ongoing membership from makerspace staff, a sense of bellowing and expected value. Participation challenges cannot be addressed through isolated interventions; they would be addressed through the means of design choices, social dynamics, and institutional structures that collectively shape how makerspaces function and who benefits from them. Efforts to improve recruitment and retention should therefore consider how these factors interact, rather than solely on individual motivation or skill deficits.

Future research may benefit from examining how intentional design and programming strategies influence participation across diverse institutional contexts. Longitudinal studies that track student engagement over time could further illuminate how value is constructed and sustained. By centering participation, belonging, and equity, this review contributes to a deeper understanding of how makerspaces can better support inclusive and meaningful engagement in engineering education.

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